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ABSTRACT

This study was conducted to investigate the effects of the animation of visual information when used in conjunction with text and static visuals in microcomputer-based instruction. Of particular interest were consequent performance on higher level learning tasks as a result of viewing these forms of visual presentation, and those levels of learning that demonstrate knowledge of a dynamic process. The 72 subjects, who were introductory psychology undergraduate students, were randomly assigned to one of three treatment groups to complete a microcomputer-based tutorial presentation of information about the structure and function of the human heart. The subjects in each treatment group were also randomly assigned to graphic or verbal testing. One treatment group received the tutorial employing text and static visuals with computer-assessed short-answer questions providing immediate feedback; the second group received the same presentation features with the addition of imagery cuing; and the third group preserved the content, sequence, and operation of the second with the addition of animated sequences of a pumping heart where appropriate. The results of the study show that the use of animation in a computer-based tutorial to teach a dynamic process can be beneficial. While this study did not clearly distinguish the impact made by the animation of visuals from that made by the imagery cuing strategy, certain results were clearly supportive of the contribution to learning made by animating the visuals. As the increased availability of hardware and software systems make the design and use of this visual form accessible, further research should be conducted on the impact of animated visual information on specific learning tasks. (10 references) (BBM)

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Title:

Learning Dynamic Processes from Animated Visuals in Microcomputer-based Instruction

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The association of the use of computer-generated visual images with specific types of learning outcomes has begun to show promising results (Rieber, 1988; Baek and Layne, 1988). While researchers exploring visual form effects on a range of learning tasks have suggested graphic detail and embedded learning strategy differences (Dwyer, 1978; Belland, Taylor, Canelos, Dwyer, and Baker, 1985; and Belland, Mayton, Dwyer, and Taylor, 1991), their results consistently show diminished performance on learning tasks related to complex interactions within a system. That is, while conclusions about the effects of visual image detail and modeled strategies for viewing visual information in microcomputer-based instructional materials are drawn for a variety of performance criteria, those tasks which require the learner to recall information about dynamic processes of a presented system yield low results. The purpose for conducting the study reported here was to determine if a particular form of visual image, namely animation, (delivered via a microcomputer-based instructional system) would enhance performance on criterion measures demonstrating the learning of dynamic processes.

Animation, the rapid display of slightly varied images in order to produce a continuous sequence of an object(s) in motion, brings a special combination of potentials to the visual world. Producing a moving sequence of images enables one to add the fourth dimension of time to a visual scene. Such an attribute allows the depiction of multivariate changes in an event(s) over time. Also, individual animation images (frames) are typically created through hand-drawn, modeled, sculpted, or computer-rendered means. Such a process affords a special attention to detail and precision. For similar reasons, the animation process permits the rendering of scenes that could be difficult, dangerous, or impossible to depict by traditional photographic, cinematic, or videographic techniques. In light of this combination of attributes, it is anticipated here that animation would be instructionally attractive for presenting information about dynamic processes.

This study was conducted to investigate the effects of the animation of visual information when used in conjunction with text and static visuals in microcomputer-based instruction. Of particular interest was consequent performance on higher level learning tasks as a result of viewing these forms of visual presentation. The specific interest was on those levels of learning that demonstrate knowledge of a dynamic process.

In addition to comparisons of contrasting forms of instructional presentations (i.e., animated versus static visuals), attention was also paid to some other presumably relevant factors in this study. Focus on the learning of dynamic processes from animation-enhanced instruction also included attention to forms of microcomputer-based materials which did and did not employ an externally-imposed, visualization strategy, to testing in both graphic- and text-based formats, and to retention of learning.

Hypotheses

Stated in the null form, the following hypotheses were tested:

Ho_1. Persons exposed to animated graphics (used with static visual images and text) in microcomputer-based instruction will not score significantly higher than persons receiving microcomputer-based instruction using static visual images and text alone on cued-recall tests of dynamic processes and related complex concepts when the performance measures are taken immediately following presentation of instruction.

Ho2. Persons exposed to animated graphics (used with static visual images and text) in microcomputer-based instruction will not score significantly higher than persons receiving microcomputer-based instruction using static visual images and text alone on cued-recall tests of dynamic processes and related complex concepts when the performance measures are taken following a one-week delay after presentation of instruction.

Ho3. Persons exposed to animated graphics (used with static visual images and text) in microcomputer-based instruction will not score significantly higher than persons receiving microcomputer-based instruction using static visual images and text alone on free-recall tests of dynamic processes and related complex concepts when the performance measures are taken immediately following presentation of instruction.

Ho4. Persons exposed to animated graphics (used with static visual images and text) in microcomputer-based instruction will not score significantly higher than persons receiving microcomputer-based instruction using static visual images and text alone on free-recall tests of dynamic processes and related complex concepts when the performance measures are taken following a one-week delay after presentation of instruction.

Design

To investigate these hypotheses, 72 introductory psychology, undergraduate students at The Ohio State University participated in a 3X2X5X2 repeated measures, factorial design study in the Autumn of 1989 and Winter of 1990. The independent variables included the three levels of instructional/presentation method employed and two visual orientations of the subsequent criterion measures. The dependent variables included the five criterion measures. In order to investigate retention of learning, these tests were administered twice, immediately after treatment exposure and following a one-week delay. Figure 1 shows the variables represented in the study. Subjects were randomly assigned to one of three treatment groups to complete a microcomputer-based tutorial presentation of information about the structure and function of the human heart. Random assignment was made again for the purpose of grouping the subjects of each treatment group for one of the two parallel forms of testing. The five performance measures were administered at that time and again following the one-week delay. Experimental arrangement is diagrammed in Figure 2.

Treatments

In each of the three treatment groups, subjects were presented information about the human heart via a combination of text and graphic images. Content and sequence for this presentation were based on materials developed by F. Dwyer (1972, 1978) for a line of studies on visual learning. Each subject viewed 54 frames (screens) of information about location and function of parts of the human heart as well as overall heart function and cycling. The text for each of the 54 frames consisted of one to four sentences (approximately ten to sixty words). A sample information screen is shown in Figure 3. The graphic images consisted of a combination of static, two-dimensional line drawings of the heart, text labels, and arrows. In each frame, the graphic depicted a lateral, posterior section of the human heart. The detail of the graphic was consistent with the form of visual generally found most effective by Dwyer [1978]. Labels consisted of a one- or two-word identifier while arrows were used to indicate a part, process, or flow.

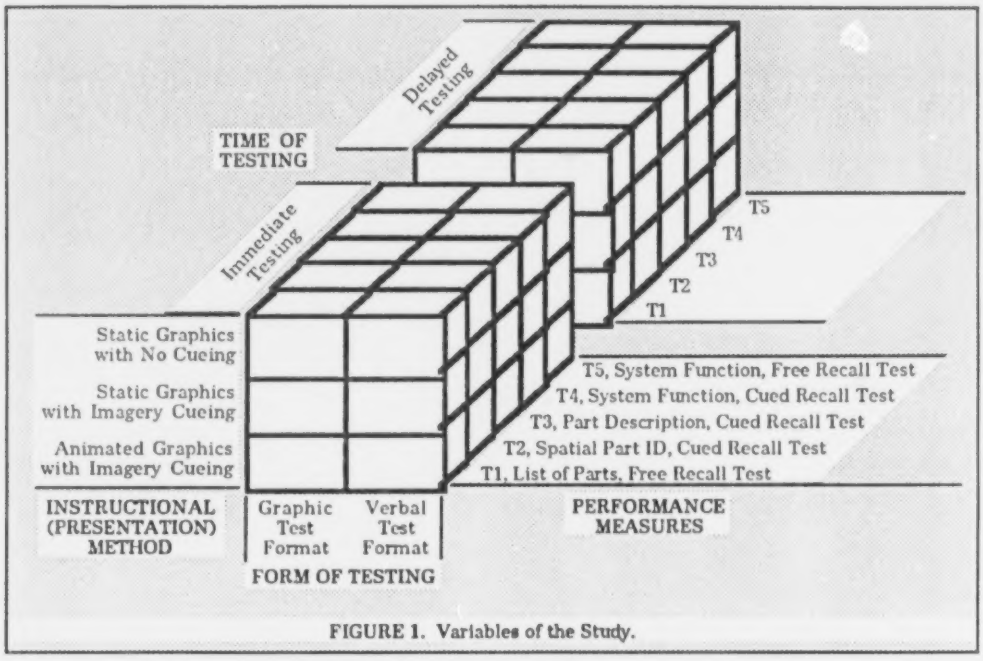

FIGURE 1. Variables of the Study.

The information frames were interspersed with 57 questions concerning the content. Computerized assessment of each response provided immediate feedback to the subject in the form of a simple message acknowledging response accuracy. When a response was incorrect, the subject received the option to repeat the specific information frames that related to that question and a second opportunity to correctly answer the question.

Treatment One: Static Visuals, No Cueing Strategy. The first treatment group received this microcomputer-based tutorial on the human heart, employing text and static visuals interspersed with computer-assessed, short-answer questions as described above.

Treatment Two: Static Visuals, Imagery Cueing Strategy. The second treatment included the same presentation features as the first with the addition of an external learning strategy developed by Taylor, Belland, Canelos, Dwyer, and Baker [1987]. This imagery cueing strategy involves the periodic inclusion (every five frames of presentation) of a special frame which shows an outline of the human heart and requests that the viewer fill in parts and operation of the heart mentally. It was anticipated that this would encourage viewers to mentally visualize the information presented, thus emphasizing the processing of visual information and enhancing the learning of the content. The second treatment, therefore, is identical to the first (static graphics and text) with the addition of the imagery cueing, learning strategy.

Treatment Three: Animated Visuals, Imagery Cueing Strategy. The third treatment preserved the content, sequence, and operation of the second with one exception. Whereas the second treatment employed static visuals, the third treatment also included animated sequences of a pumping heart, where appropriate. The animated visuals were appropriately incorporated in the 54 frames of information described above to depict changes in shape, flow of blood, and movement of parts

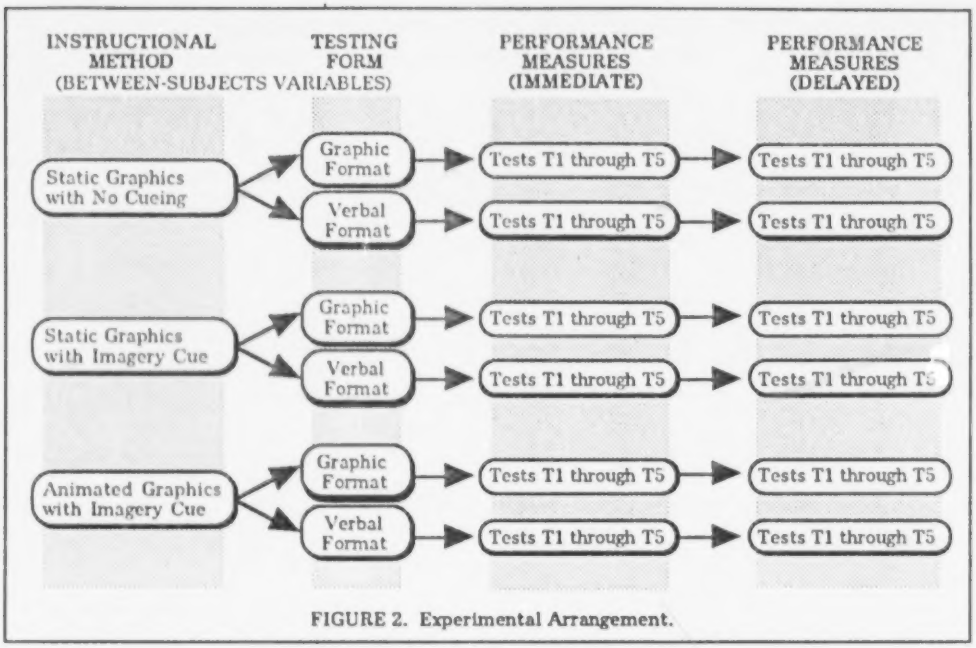

FIGURE 2. Experimental Arrangement.

within the heart. The animation consisted of the cycling of an entire set of 16 images of the human heart or an appropriate subset of the 16 images.

Rendered detail of the graphics for both treatments was identical (i.e., two-dimensional, non-shaded, line drawings of the heart in cross-section). But, in those instances when the text described a process over time, the visual became animated to depict the information over the added dimension.

Criterion Measures

Following exposure to the treatments, each subject was randomly assigned to one of two testing groups for completion of a set of five tests measuring performance on a variety of learning tasks. One testing group completed the five tests written in a format dominant in a verbal orientation, while the other group completed a parallel set of tests which emphasized stronger reliance on the graphic elements This graphic form of test was developed and validated by C. Dwyer (1984). The five tests measured (a) list learning tasks of cardiac part names (in a free recall format); (b) spatial, cued-recall tasks of part identifications; (c) simple concept learning tasks (description of parts, cued-recall); (d) complex concept learning tasks (cued recall of system operations); and (e) free-recall, problem solving tasks (integration of part morphology, part physiology, and system operation). Each of the tests was scored on a twenty point scale.

Test One (T1): Free Recall of Cardiac Part Names. The list learning task of Test T1 required the learner to list the names of the parts of the heart and its phases as recalled from the tutorial. Both the verbal and graphic forms of test groups completed the same version of this test.

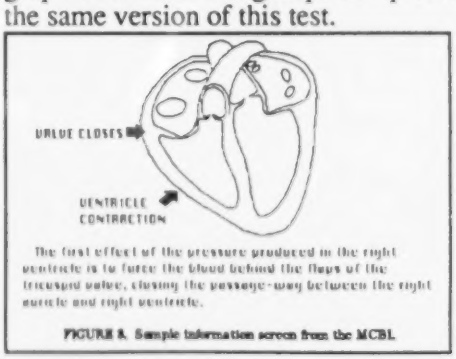

FIGURE 3. Sample information screen from the MCBI.

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Test Two (T2): Cued Recall of Cardiac Part Identification. Test T2 was a cued-recall measure of the identification of part locations in the heart. Twenty multiple choice items tested the proper identification of a part name in a line drawing of a cross section of the human heart (comparable to ones used in the microcomputer-based instruction). For the verbal form of the test, subjects were asked to identify the correct name (from a list of five) corresponding to a numbered arrow indicating a specific location in the drawing. In the graphic form of the test, subjects were asked to identify which of five labeled arrows designated a specified part name.

Test Three (T3): Cued Recall of Cardiac Part Description. Test T3 represented a simple concept learning task in which learners were required to identify a part by name after being given a description of its structure or function. In the verbal form, this involved selecting the correct name from a list of five to complete a simple statement describing the structure or function of an individual part. The graphic form, called for the selection of a labeled arrow to match the statement about a part.

Test Four (T4): Cued Recall of Cardiac System Functions. Test T4, the cued-recall of system functions, demanded that the learner make responses about relationships among parts of the heart and the cycling of the heart beat. Twenty multiple-choice items involved the complex concept learning task of identifying the appropriate part name(s) or term(s) which best completed a statement about the functions within the human heart. The graphic form of the test accomplished this by asking the learner to choose (from among four drawings of the heart) the one which best depicted the situation described in the item.

Test Five (T5): Free Recall of Cardiac System Functions. The free recall test of system functions (T5) involved the writing or drawing of cardiac system spatial arrangements and functions. The verbal form required that the learner write an essay describing the structure and function of the human heart as recalled from the computer tutorial. This was to include names and location of parts as well as a description of the pumping of blood and related phases. The graphic form required the same information, only drawn in picture form by the learner. Labels and arrows showing parts and blood flow were encouraged.

For the delayed testing session, identical forms of tests T1 through T5 were administered.

Test score results were analyzed through analysis of variance with repeated measures on a university mainframe computer using the SAS© statistical package. For post hoc analysis of multiple comparisons, the Student-Newman-Keuls Test was employed.

Results

The descriptive statistics for performances measured by the five criterion measures are shown in Tables 1 and 2 (immediate and delayed testing sessions, respectively). Graphical representations of these data are depicted in Figures 4 through 9.

From the ANOVAs conducted on the data, the following measurements of significance were made:

1. The animated visual treatment produced higher scores than the static visual treatment with no imagery cueing ($p<.05$, $F=3.37$, $df=2$) on the cued-recall test of system functions when administered immediately after treatment. (See Tables 3 and 4.)

TABLE 1
Descriptive Statistics for Immediate Testing Results

	Learning Tasks									
	T1		T2		T3		T4		T5	
	List of Parts		Part Ident.		Part Descript.		System Fns		System Fns	
	Free Recall		Cued Recall		Cued Recall		Cued Recall		Free Recall	
Treatment Groups	M	SD	M	SD	M	SD	M	SD	M	SD
Static Visual, No Cueing										
Graphic Form of Test	11.83	4.43	13.42	3.29	12.75	3.17	11.42	4.06	6.83	2.35
Verbal Form of Test	13.42	3.37	11.67	4.68	10.00	3.98	9.42	2.78	8.00	2.73
Both Forms	12.63	3.93	12.54	4.05	11.38	3.79	10.42	3.55	7.42	2.56
Static Visual, Imagery Cue										
Graphic Form of Test	13.75	4.00	12.67	3.87	10.92	5.45	12.75	4.03	8.04	4.61
Verbal Form of Test	14.33	3.23	12.17	4.47	11.92	4.03	12.25	2.83	10.33	3.93
Both Forms	14.04	3.57	12.42	4.10	11.42	4.72	12.50	3.41	9.19	4.35
Animated Visual, Imagery Cue										
Graphic Form of Test	15.50	4.01	14.83	2.98	12.83	4.61	12.50	4.10	10.50	3.04
Verbal Form of Test	14.92	3.40	14.67	3.75	13.92	3.53	13.33	3.39	13.88	4.46
Both Forms	15.21	3.65	14.75	3.31	13.38	4.05	12.92	3.71	12.19	4.11
All Treatments	13.96	3.82	13.24	3.93	12.06	4.25	11.94	3.68	9.60	4.20

Note: Maximum score = 20. $n = 72$.

TABLE 2
Descriptive Statistics for Delayed Testing Results

	Learning Tasks									
	T1		T2		T3		T4		T5	
	List of Parts		Part Ident.		Part Descript.		System Fns		System Fns	
	Free Recall		Cued Recall		Cued Recall		Cued Recall		Free Recall	
Treatment Groups	M	SD	M	SD	M	SD	M	SD	M	SD
Static Visual, No Cueing										
Graphic Form of Test	8.33	4.48	12.17	4.43	12.08	3.70	10.42	3.96	8.71	3.07
Verbal Form of Test	11.42	4.52	9.67	5.07	7.67	3.98	8.42	3.45	5.58	2.53
Both Forms	9.88	4.67	10.92	4.83	9.88	4.39	9.42	3.78	7.15	3.18
Static Visual, Imagery Cue										
Graphic Form of Test	10.00	6.45	11.58	4.50	11.17	4.73	10.75	4.86	7.21	5.01
Verbal Form of Test	14.00	5.08	10.92	4.72	10.75	4.58	11.08	3.45	8.33	4.47
Both Forms	12.00	6.04	11.25	4.52	10.96	4.55	10.92	4.13	7.77	4.68
Animated Visual, Imagery Cue										
Graphic Form of Test	13.00	5.48	14.08	2.84	12.92	3.65	12.25	3.44	8.83	2.85
Verbal Form of Test	12.17	4.73	12.83	3.79	11.75	4.11	12.83	2.98	11.54	5.07
Both Forms	12.58	5.02	13.46	3.34	12.33	3.85	12.54	3.16	10.19	4.25
All Treatments	11.49	5.33	11.88	4.37	11.06	4.33	10.96	3.88	8.37	4.24

Note: Maximum score = 20. $n = 72$.

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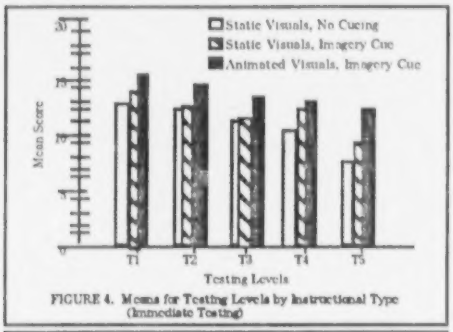

FIGURE 4. Means for Testing Levels by Instructional Type (Immediate Testing)

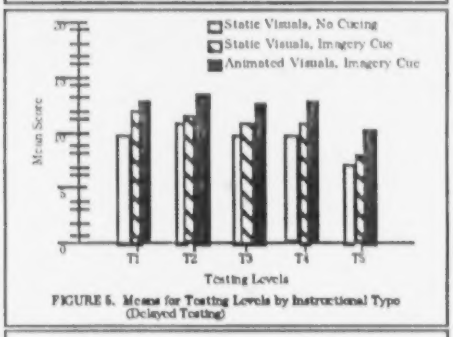

FIGURE 5. Means for Testing Levels by Instructional Type (Delayed Testing)

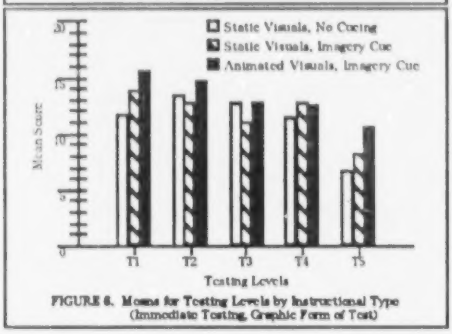

FIGURE 6. Means for Testing Levels by Instructional Type (Immediate Testing, Graphic Form of Test)

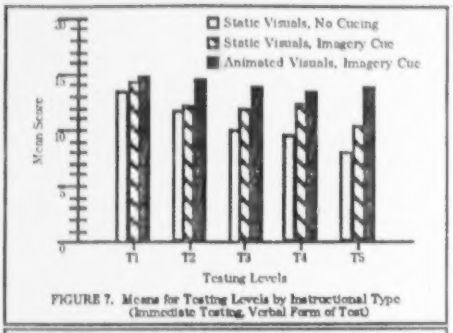

FIGURE 7. Means for Testing Levels by Instructional Type (Immediate Testing, Verbal Form of Test)

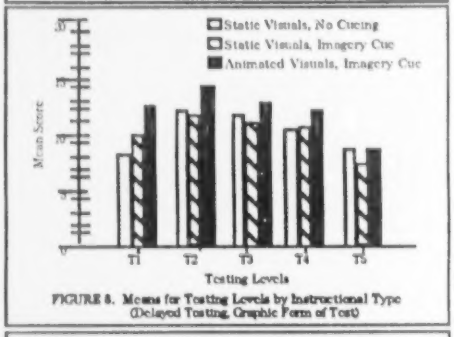

FIGURE 8. Means for Testing Levels by Instructional Type (Delayed Testing, Graphic Form of Test)

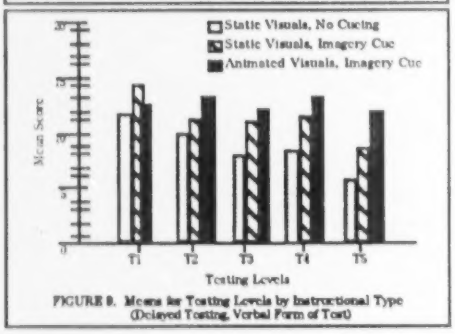

FIGURE 9. Means for Testing Levels by Instructional Type (Delayed Testing, Verbal Form of Test)

2. The static visual treatment with imagery cueing produced higher scores than the static visual treatment with no imagery cueing ($p<.05$, $F=3.37$, $df=2$) on the cued-recall test of system functions when administered immediately after treatment. (See Tables 3 and 4.)

3. The animated visual treatment produced higher scores than the static visual treatment with no imagery cueing ($p<.05$, $F=4.09$, $df=2$) on the cued-recall test of system functions when administered one week after treatment. (See Tables 3 and 5.)

4. The animated visual treatment yielded higher scores than each of the static visual treatments with and without imagery cueing ($p<.001$, $F=10.64$, $df=2$) on the free-recall test of system functions when administered immediately after treatment. (See Tables 6 and 7.)

5. The static visual treatment with imagery cueing yielded higher scores than the static visual treatment without imagery cueing ($p<.001$, $F=10.64$, $df=2$) on the free-recall test of system functions when administered immediately after treatment. (See Tables 6 and 7.)

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6. Due to an interaction between instructional method and form of test ($p<.05$) for the delayed testing of the free-recall test of system functions, follow-up analyses were made by individual form of test. (See Table 8.)

7. For the verbal form of the free-recall test of system functions, the animated visual treatment yielded higher scores than the static visual treatment with no imagery cueing ($p<.01$, $F=6.15$, $df=2$) when the test was administered one week after treatment. (See Table 9.)

Table 10 summarizes these results.

Discussion

In this study, the primary focus was on learning higher order concepts (namely dynamic processes involving changes in multiple variables over time) aided by the animation of graphic, instructional elements. Dynamic process was exemplified in the content (delivered by the instructional treatments) as (a) the simultaneous functioning of several parts of the human heart, (b) relationships among parts, and (c) the resulting overall function of the cardiac system through the consequent heart beat cycle.

To indicate the learning effects of animated visuals in the presentation, significant measures in the fourth and fifth tests (cued- and free-recall of cardiac system functions) were sought.

As expected, those tests which did not demonstrate learning of dynamic processes (tests T1 through T3 – list learning of part name, part location identification, and part description) did not show any significant differences among the treatment groups for variations in the instructional method (i.e., visual form or cueing strategy). However, where it was anticipated that the inclusion of animated information would be most effective (tests T4 and T5 – tests of cardiac system functions), significant differences were measured.

On both tests of system operations (cued and free recall), when tested immediately after treatment exposure, learners who experienced the microcomputer-based instruction with animated graphics outperformed those seeing only the static form and no imagery cue strategy.

In fact, both groups who experienced the imagery cue (animated and static graphics) significantly outperformed those who viewed the static visuals, no cue treatment form in the immediate testing session. This leaves some uncertainty as to whether the measured differences should be attributed to the inclusion of the animation or the presence of the embedded cueing strategy.

Two patterns of results, however, may suggest a clearer contribution by the form of visuals.

It was observed that the animated-visual group maintained superiority of performance over the static-visual, no-cue group following the one week delay, while the static-visual, imagery-cue group could not. This pattern of retention was consistent in both formats (graphic and verbal) of the cued-recall test as well as in the verbal format of the free-recall test. This more strongly suggests the role of the animated visual in learning dynamic processes. It appears that subjects in the group experiencing the animated visual treatment were able to better retain information about how the cardiac system operates. Those viewing only static visuals could not be differentiated by the imagery cueing technique following the delay between instruction and testing.

The most pronounced contrast in this study occurred with the immediate

TABLE 3.
Analysis of Variance of
Performance on the Cued Recall of System Functions
by Instructional Methods, Form of Test, and Time of Test

Source	df	SS	MS	F
Between Ss	71	1798.1597		
Instructional Method (A)	2	194.5972	97.2986	4.14*
Test Form (B)	1	7.5625	7.5625	0.32
Method X Form (AB)	2	46.5417	23.2708	0.99
Error Between (S/AB)	66	1549.4583	23.4766	
Within Ss	72	263.5000		
Time of Test (C)	1	35.0069	35.0069	10.62**
Method X Time (AC)	2	8.7639	4.3819	1.33
Form X Time (BC)	1	0.3403	0.3403	0.10
Method X Form X Time (ABC)	2	1.9306	0.9653	0.29
Error Within (SC/AB)	66	217.4583	3.2948	
Total	143	2061.6597		

* p < .05
** p < .01
*** p < .001

TABLE 4.
Analysis of Variance of
Performance on the Cued Recall of System Functions
by Instructional Methods and Form of Test (Immediate Testing)

Source	df	SS	MS	F
Instructional Method (A)	2	86.1111	43.0556	3.37*
Test Form (B)	1	5.5556	5.5556	0.43
Method X Form (AB)	2	24.1111	12.0556	0.94
Error (S/AB)	66	844.0000	12.7879	
Total	71	979.7778		

* p < .05
** p < .01
*** p < .001

TABLE 5.
Analysis of Variance of
Performance on the Cued Recall of System Functions
by Instructional Methods and Form of Test (Delayed Testing)

Source	df	SS	MS	F
Instructional Method (A)	2	117.2500	58.6250	4.19*
Test Form (B)	1	2.3472	2.3472	0.17
Method X Form (AB)	2	24.3611	12.1806	0.87
Error (S/AB)	66	922.9167	13.9836	
Total	71	1066.8750		

* p < .05
** p < .01
*** p < .001

TABLE 6.
Analysis of Variance of
Performance on the Free Recall of System Functions
by Instructional Methods, Form of Test, and Time of Test

Source	df	SS	MS	F
Between Ss	71	2286.0815		
Instructional Method (A)	2	384.4618	192.2309	7.28**
Test Form (B)	1	56.8767	56.8767	2.15
Method X Form (AB)	2	100.6701	50.3351	1.91
Error Between (S/AB)	66	1743.0729	26.4102	
Within Ss	72	297.6250		
Time of Test (C)	1	54.3906	54.3906	21.89***
Method X Time (AC)	2	18.5729	9.2865	3.74*
Form X Time (BC)	1	37.5156	37.5156	15.10***
Method X Form X Time (ABC)	2	23.1563	11.5781	4.66*
Error Within (SC/AB)	66	163.9896		
Total	143	2583.7066		

* p < .05
** p < .01
*** p < .001

TABLE 7.
Analysis of Variance of
Performance on the Free Recall of System Functions
by Instructional Methods and Form of Test (Immediate Testing)

Source	df	SS	MS	F
Instructional Method (A)	2	279.1736	139.5868	10.64***
Test Form (B)	1	93.3889	93.3889	7.12**
Method X Form (AB)	2	14.6319	7.3160	0.56
Error (S/AB)	66	868.1250	13.1231	
Total	71	1255.3194		

* p < .05
** p < .01
*** p < .001

TABLE 8.
Analysis of Variance of
Performance on the Free Recall of System Functions
by Instructional Methods and Form of Test (Delayed Testing)

Source	df	SS	MS	F
Instructional Method (A)	2	123.8611	61.9306	3.93*
Test Form (B)	1	1.0035	1.0035	0.06
Method X Form (AB)	2	109.1944	54.5972	3.46*
Error (S/AB)	66	1040.9375	15.7718	
Total	71	1274.9965		

* p < .05
** p < .01
*** p < .001

testing of the free recall of system functions. On this level, the performances of learners who viewed the animated presentation were significantly higher than those of learners who saw the static form, both with and without the imagery cue. In this case, learners appear to have been helped by seeing the heart animated for the free-recall task, when performed immediately following instruction.

Conclusion

The results of this study show that the use of animation in microcomputer-based instruction to teach a dynamic process can be beneficial. While the present study did not clearly distinguish the impact made by the animation of visuals from that made by the presence of an external, mental imaging strategy in all aspects, certain

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TABLE 9.
Analysis of Variance of
Performance on the Delayed Testing of Free Recall of System Functions
by Instructional Methods for Graphic and Verbal Forms of Test

Source	df	SS	MS	F
Graphic Form of Test	35	488.2500		
Instructional Method (A)	2	19.6250	9.8125	0.69
Error (S/A)	33	468.6250	14.2008	
Verbal Form of Test	35	765.7431		
Instructional Method (A)	2	213.4306	106.7153	6.15**
Error (S/A)	33	572.3125	17.3428	

* p < .05
** p < .01
*** p < .001

results were clearly supportive of the contribution to learning made by animating the visuals. Maintained significance in the retention measures and association of significance to the specific learning tasks associated with dynamic processes presented from the content, suggest potential areas of focus for further study.

This study, like others recently reported links the use of animation in microcomputer-based instruction to specific learning outcomes. Such linkage of the use of a visual form to a particular instructional purpose implies the complex relationship between forms of visual information and instructional function.

From an instructional design perspective, it appears that the inclusion of animation adds another facet to the visual qualities of instructional systems. Benefitting from computer-based authoring systems which boast improved memory, processing times, and functionality, instructional designers are likely to exercise this increasing capability to produce greater numbers of animation-enhanced, microcomputer-based instructional systems. As the increased availability of hardware and software systems make the design and use of this visual form accessible, further evidence of the impact of animated visual information on specific learning tasks (e.g., knowledge of dynamic processes) merits further attention and exploration.

TABLE 10.
Summary of Analyses of Variance of
Performance on the Recall of Cardiac System Functions

	Instructional Methods		
Performance Measures	Static Visuals, No Cueing (SVNC) superior to:	Static Visuals, Imagery Cue (SVIC) superior to:	Animated Visuals, Imagery Cue (AVIC) superior to:
Cued Recall of System Functions			
Immediate Testing (H01)	----	SVNC*	SVNC*
Delayed Testing (H02)	----	----	SVNC*
Free Recall of System Functions			
Immediate Testing (H03)	----	SVNC***	SVIC, SVNC***
Delayed Testing (H04)			
Graphic Form of Test	----	----	----
Verbal Form of Test	----	----	SVNC**

* p < .05
** p < .01
*** p < .001

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